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Military Aviation: A Contact Lens Review (Reprint)

By

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Sensory Research Division

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The military aviation communities have benefitted from the development of advanced electro-optical avionics systems. One drawback that has emerged is an increasing system incompatibility with traditional spectacle visual corrections. An alternative solution to the refractive error correction problem that some services have been investigating is that of contact lens wear. Since this much-debated topic is currently of command interest, a general overview of contact lens issues is presented as a framework for future discussions.

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SCIENCE NEWS NOTE

Military Aviation: A Contact Lens Review

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The military aviation communities have benefitted from the development of advanced electro-optical avionics systems. One drawback that has emerged is an increasing system incompatibility with traditional spectacle visual corrections. An alternative solution to the refractive error correction problem that some services have been investigating is that of contact lens wear. Since this much-debated topic is currently of command interest, a general overview of contact lens issues is presented as a framework for future discussions.

RECENT TECHNOLOGICAL advances have had a major impact on military aviation. While modern methods of providing visual information via electro-optics/visionics systems have extended the aviator's operational envelope, these devices are becoming increasingly incompatible with spectacle wear. Due to unique stringent regulations, the Navy and Marine Corps do not allow servicemembers with high refractive errors (i.e., uncorrected visual acuity worse than 20/70) to pilot aircraft equipped with these advanced visionics systems; if an aviator develops an excessive refractive error, administrative reassignment as a flight officer (bombardier/navigator, radar intercept officer) ensues (25). Alternatively, Navy/Marine Corps aviators with uncorrected visual acuity from 20/25 to 20/70, correctable to 20/20 or better, are permitted to operate these high performance aircraft. This type of partial deselection process has, for the moment, been rejected by the Army and Air Force. Since close to 20% of Army aviators (29) and 27% of Air Force aviators (9) are ametropic (spectacle wearing), and since an increasing percentage of training applicants are ametropic, alternative means of providing a refractive error correction need to be investigated.

One alternative being considered is the use of a contact lens correction. Current and past armed forces regulations have prohibited aviators from wearing contact lenses while flying. However, waivers to these regulations have been approved at certain locations where controlled scientific investigations are being conducted. Because of differences in missions and operational scenarios, research efforts are being directed along somewhat divergent paths. Air Force concerns concentrate on low atmospheric pressure/low ambient oxygen issues, low relative humidity, and high G-force effects on daily lens wear. Army concerns center on the operational field environment, its impact on proper lens hygiene (cleaning and disinfection), and the physiological/biochemical response of the cornea to extended contact lens wear. Since the question of contact lens use by aviation personnel is a matter of current interest throughout the aviation and aeromedical communities, this review provides a general overview of salient issues and considerations.

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Aviation Literature Review

A number of types of contact lenses have been evaluated within the aviation environment. The first Army Aviation study was in 1974 (7). Of concern at the time was the fact that "hard" polymethylmethacrylate (PMMA) contact lenses were prone to dust particle interference between the cornea and the contact lens when worn by ground troops in an operational environment (22,30,31). Since Army aviators routinely were exposed to dusty environments, the PMMA lenses had been ruled out as an Army aviator optical correction. The Bausch and Lomb (B & L) "Soflens®" was found to be free of dust-induced foreign body problems. However, an unacceptable variability in visual acuity did result. A parallel study (28) obtained similar results concerning both absence of dust and dirt problems and variable visual acuity in a population of Israeli military and civilian pilots. Acuity variation was not attributed to any specific origin.

Since soft contact lenses have a moderate to high water content, other studies have been concerned with the effects of both low atmospheric pressure and low relative humidity on lens dehydration and corneal health. A number of clinical case reports concerning extended passenger travel difficulties with contact lenses had been published (5,6,21) serving to stimulate specific laboratory investigations. A hypobaric chamber study simulating altitudes up to 30,000 ft on the B & L "Soflens®" failed to demonstrate an effect on contact lens wearability (13). However, in a study by Forgie (17) with simulations at 25,000 ft for 2.5 h and at 9,000 ft for 6 h, subjects demonstrated some tear film debris and experienced minor discomfort. Despite these findings, aircraft control was not significantly degraded, and visual acuities were said not to be affected. Forgie's finding agreed with those of Hapnes (20), whose subjects were kept at 1/2 atmosphere for 4 h. All subjects exhibited minor objective corneal changes that appeared to be epithelial in origin. More recently, the U.S. Air Force conducted a series of hypobaric chamber "flights" to assess soft contact lens wear at altitude (16). Indicators of physiological stress to the cornea (by slit lamp examination) showed heightened responses at altitude with contact lenses. However, these changes occurred without measurable degradation in vision and did not preclude the normal wear of soft contact lenses.

Another recent study (15) has documented subcontact lens bubble formation in a hypobaric chamber protocol. Soft contact lens bubble formation was limited to the lens periphery, and did not adversely affect vision or corneal epithelium integrity. Rigid, gas-permeable lenses primarily form central bubbles, with potentially adverse effects on vision and the corneal epithelium. Similar bubble formation has been documented in hyperbaric decompression studies for the Navy (26,33).

Since PMMA lenses had a propensity for accidental displacement from the central cornea, centrifuge studies also have been performed on soft contact lens-wearing subjects (17). A 5.1 $+G_z$ force at eye level induced a subject-variable displacement, but never enough to leave the pupil uncovered by the optical zone of the lens. An anecdotal report (27) stated that one fighter pilot, over a 3-year period, encountered no problems with gravity forces up to 6 $+G_z$. In U.S. Air Force centrifuge studies, forces of up to 8 $+G_z$ failed to significantly interfere with the visual acuity and physical fit of soft contact lens wearing subjects (14). Similar work with rigid gas permeable lenses has been recently completed.[1]

Draeger, in the Federal Republic of Germany (12), addressed all three of the above areas of interest in one study. His results indicated: 1) low atmospheric pressure does not induce a problem in modern, well-fitted lenses; 2) low humidity does not cause significant corneal or conjunctival irritation; 3) high G loads do not significantly affect lens positioning on the cornea. Braithwaite (3) described the experiences of seven British Army aviators wearing several different types of contact lenses; among the conclusions was the statement that soft lenses were generally better tolerated than hard lenses. In a study from the United Kingdom, 17 officer aircrew were fitted with medium (50%) and high (75%) water content extended-wear soft contact lenses (4). The subjects were exposed to hypoxia, rapid decompression, pressure breathing, vibration, extremes in climate, G forces, and the prolonged wearing of an aircrew respirator during the course of the flight-simulation study. The authors reported that visual performance of soft contact lens-wearing subjects, under the flight simulation ground-testing conditions, did not differ significantly from the control group. They concluded that soft contact lenses are acceptable for aircrew use. Reportedly, the Royal Air Force is currently authorizing contact lens use on a limited basis (8).

In contrast to the above conclusion, two retrospective epidemiological studies have suggested that civilian contact lens-wearing aviators may be more likely to be involved in mishaps than the spectacle-wearing and visually "normal" civilian aviation populations (10,11). Despite the apparent controversy, Air Force researchers have stated that contact lenses appear to be a viable alternative for their own spectacle compatibility problems. However, they did express concerns regarding implementation of wide-spread usage (35).

The U.S. Air Force recently concluded a field test of contact lens use by Tactical Air Command (TAC) aviators (9). The joint operational test was conducted by the U.S. Air Force School of Aerospace Medicine (USAFSAM) and the Tactical Air Warfare Center (TAWC). A total of 85 aircrewmembers from 5 TAC bases participated in this test of two different water content soft contact lenses. Although divided into three separate phases with interim completion dates, the conclusion of the study and the final report will be published soon. Based on preliminary results, the Air Force has approved the use of soft contact lenses for all ametropic aviators.[2]

Several U.S. Army organizations have addressed a variety of aspects of contact lens wear in military aviation. In order to develop relative safety patterns in established Army rotary-wing systems, an initial feasibility study of contact lens wear involved volunteer National Guard aviators at Fort Indiantown Gap, PA (19). Plano powered, FDA approved extended-wear contact lenses were fitted to the nondominant eye of volunteer aviators. Of 35 volunteers, 34 were adequately fitted with a 55% water content soft lens. Administrative (scheduling) losses totalled 5, so that the actual subject sample size was 29. During the 63-d course of the 30-d lens wear protocol, six subjects were unsuccessful in the program (four as a result of mild conjunctivitis believed to be seasonal in nature, one as a result of a corneal abrasion and secondary withdrawal, one resulting from lost lenses with no access to replacement lenses). No incidents of operational significance were reported, and the author summarized that this monocular fitting methodology could be applied to large scale research efforts in the future.

Following that preliminary report, another investigation conducted by the U.S. Army Aeromedical Research Laboratory (USAARL) used Army ametropic aviators qualified in a number of different aircraft as

[1] Poster presentation by Dennis R and Miller B at the American Academy of Optometry Annual Meeting, December 1989, New Orleans.

[2] USAF Contact Lens Implementation Plan (89-73) dated 21 June 1989.

volunteer contact lens wearers, in order to further document aviation safety and flight operations issues (1). In that study, 44 aviators were fit with extended-wear contact lenses, both soft and rigid gas permeable; the lenses were worn on a 7-day/6-night schedule. That is, after the initial fitting, the lenses were worn continuously for 7 days and 6 nights. The lenses were then removed prior to retiring for the 7th night, and were reapplied the following morning after an appropriate disinfection and lens-care regimen. Post-fitting follow-up examinations were provided on day 1, day 8, and every 30 d thereafter. The study ran for 6 months with an 86% wearing success rate.

Prior to the initial contact lens fitting, the mean flying time for the subject sample was 2,136 h; over the 6-month period of the study, the mean flying time for the subjects wearing contact lenses was 294 h. During the course of the study, no groundings occurred for contact lens-related reasons, and there were no aircraft accidents involving the test subjects. Subjective performance assessments rated the contact lenses as being superior to spectacle wear for a majority of the aviators for: preflight (68%), takeoffs (83%), routine flight (83%), nap-of-the-Earth (NOE) flight (89%), night vision goggle (NVG) flight (88%), instrument flight (83%), and mission oriented protective posture (MOPP 4; i.e., in fully protecting clothing with protective mask in place) conditions (100%).

Temporary discontinuance of contact lens wear occurred nine times in six pilots. The affected aviators merely wore their spectacles in lieu of the contact lenses. A total of 6 of the original 44 subjects were unable to complete the study. Reasons for withdrawal from this voluntary study were: acuity (two) and discomfort (four). In summary, the initial feasibility study demonstrated the safe short-term use, both in medical and flight terms, of extended-wear contact lenses by Army aviators. Currently, USAARL is conducting an evaluation of a disposable, extended-wear, soft contact lens within the ametropic AH-64 Apache pilot population at Fort Rucker, AL (23). A worldwide effort, using a variety of soft and rigid lenses among ametropic aircrew members assigned to certain AH-64 attack battalions, began the summer of 1989 (24). Currently over 150 volunteer Army aircrew from 5 different locations outside the continental United States and 4 different continental United States locations are participating in this protocol.

A number of reports have documented the use of contact lenses in a military field environment other than aviation. Gavreau (18) fitted soft lenses to freefall parachutists. If protective goggles remained on the eye throughout the course of the jump, no untoward effects of soft lens wear were encountered. However, if the protective goggles and/or the soft lenses were blown off the face, the post-jump slit lamp evaluation revealed corneal epithelial punctate staining and temporarily reduced visual acuity. The staining was interpreted as an indicator of lens adherence to the superficial aspect of the corneal epithelium.

Van Norren (36) submitted a questionnaire to 100 Dutch Army contact lens wearers immediately after a large-scale field exercise; 60% were able to wear their lenses throughout the duration of the exercise. Of the respondents, 20% did not wear their lenses at all on the exercise, while 20% had started the exercise wearing their lenses but were forced to discontinue wear for one reason or another. In effect, of those respondents attempting to wear their lenses during the exercise, 60 of 80 (75%) were successfully able to do so.

Another Dutch Army study (32) evaluated soft contact lens wear by 28 soldiers over a 3-month period. During that time 29% of the subjects were forced to discontinue lens wear, yielding a success rate of 71%. Similarly, a combined U.S. Army study (2,34) of 215 armor troops over a 6-month period established a success rate for contact lens wear in garrison and field training environments at 74%.

Summary

Based on the volume and detail of available operational evidence, contact lenses outwardly appear to have a valid place in the military aviation environment. However, factors not considered in this review must be appraised. Not everyone can obtain clear and comfortable vision while wearing contact lenses. Additionally, a consistent and reliable bifocal contact lens is not yet available, although some promising concepts are under civilian study. Since the most accomplished aviators have often matured into presbyopia, a significant portion of the military's most highly skilled pilot population would not be correctable with contact lenses. Lastly, a number of physiological, biochemical, and clinical issues associated with contact lens wear have yet to be resolved. Consequently, contact lenses likely represent only a partial solution to spectacle incompatibility problems. Only a coordinated, multi-discipline approach to systems development will provide the final combination of elements necessary for long-term success in dealing with optical compatibility issues.

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